G+G
-2013

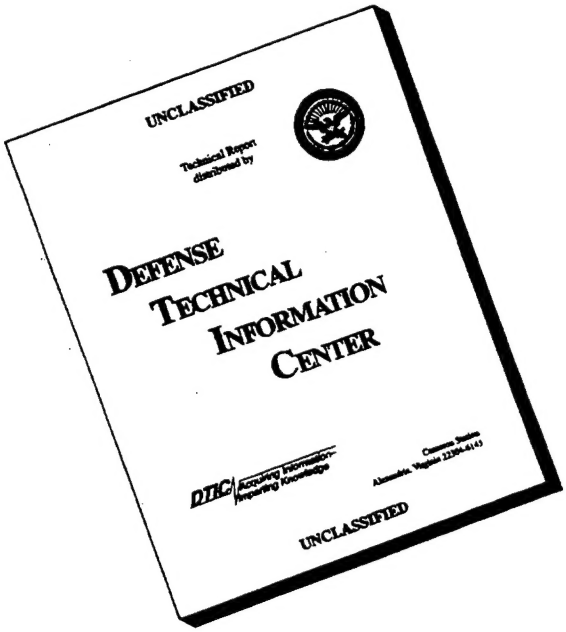
EDGERTON, GERMESHAUSEN & GRIER, INC.

FIREBALL CALCULATIONS
SHOT HAMILTON
OPERATION HARDTACK PHASE II
PROJECT 15.1

BOSTON, MASSACHUSETTS • LAS VEGAS, NEVADA
SANTA BARBARA, CALIFORNIA

REPORT NO. B-2013
29 JANUARY 1960

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

ISST

29 May 1996

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OCD/Mr. Bill Bush

SUBJECT: Documents for DTIC System

There is no record of your office receiving the following reports:

EGG-B-2024 (29 January 1960)
Fireball Calculations Shot Sanford
Operation Hardtack Phase II
Project 15.1

EGG-B-2013 (29 January 1960)
Fireball Calculations Shot Hamilton
Operation Hardtack Phase II
Project 15.1

Both documents are now approved for public release.

Therefore, we are transmitting copies for inclusions into the DTIC system, if not already there.

Enclosure:
A/S

Ardith Jarrett
ARDITH JARRETT
Chief, Technical Support

FIREBALL CALCULATIONS

SHOT HAMILTON

OPERATION HARDTACK, PHASE II

PROJECT 15.1

Report No. B-2013
29 January 1960

Prepared by R. C. Schneiderhan

Approved by D. F. Seacord, Jr.

EDGERTON, GERMESHAUSEN & GRIER, INC.
Boston, Mass. Santa Barbara, Calif. Las Vegas, Nev.

FIREBALL CALCULATIONS: SHOT HAMILTON

1.0 INTRODUCTION

Shot Hamilton, a 50-foot tower shot sponsored by LRL, was detonated at 0800 PST, on 15 October 1958 in Area TF-1 of the Nevada Test Site. The fireball yield was 0.43 ton ± 0.09 ton.

2.0 CAMERA INSTRUMENTATION AND OPERATION (Table 1)

Photographic coverage of Hamilton fireball growth was provided by two high-speed Eastman cameras and one high-speed 16 mm Fastax camera at Station 527.01 (6 x 6 No. 2) and a similar camera complement at Station 527.02 (6 x 6 No. 3). In addition, two Rapatronic cameras were located at Station 527.01 to record early fireball growth. The EG&G framing camera, running at an approximate speed of 15,000 frames per second, was located at Station F-732 (6 x 6 No. 1) to record additional early fireball behavior. One Eastman camera from Station 527.02 did not record the complete fireball. All other cameras obtained records suitable for analysis.

The station locations and the burst location are shown in Fig. 1. Figure 2 contains a summary of the survey data.

3.0 RESULTS

Because the yield of Hamilton was well below the range of constant ϕ^5 scaling[1], the ϕ comparison technique as defined in EG&G Report No. B-1869, "Fireball Calculations – Shot Eddy", was employed to determine the yield. A yield of 0.43 ton ± 0.09 ton is indicated.

1 ϕ^5 scaling is usually applicable only for yields greater than 2 kt.

An air density of 1.098 grams per liter was used in the yield calculations. The air density value was based upon a pressure of 910 millibars, a temperature of 15.0°C, and a relative humidity of 30 percent at shot time.

The table below gives the comparison shots, and the Hamilton yield obtained by the ϕ - comparison.

Comparison Shot	Hamilton Yield (tons)
Balloon	
La Place	0.495
Wheeler	0.374
Santa Fe	0.499
Lea	0.452
Hidalgo	0.450
Air Drop	
Buster B	0.404
Wasp	0.408
Ranger A	0.398
Wasp	0.419
Ranger E	0.423

Comparison Shot	Hamilton Yield (tons)
Tower	
Hornet	0,422
UK-3	0.419
Rio Arriba	0.456
Quay	0.431
	$\overline{W}$ = 0.432

Diameter vs time and ϕ vs time plots are shown in Figs. 3, 4, and 5.

The following data sheets are included for each film:

(a) Photo Plan and Photo Loading Chart

(b) Camera Data and Calculation Sheet

(c) Diameter Measurement Sheet

(d) E102 print-out sheet of D, t, and ϕ.

Selected frames of fireball films are contained in the Appendix.

The zero-frame times of the motion picture camera records were determined by comparing these records with the Rapatronic diameter vs time data.

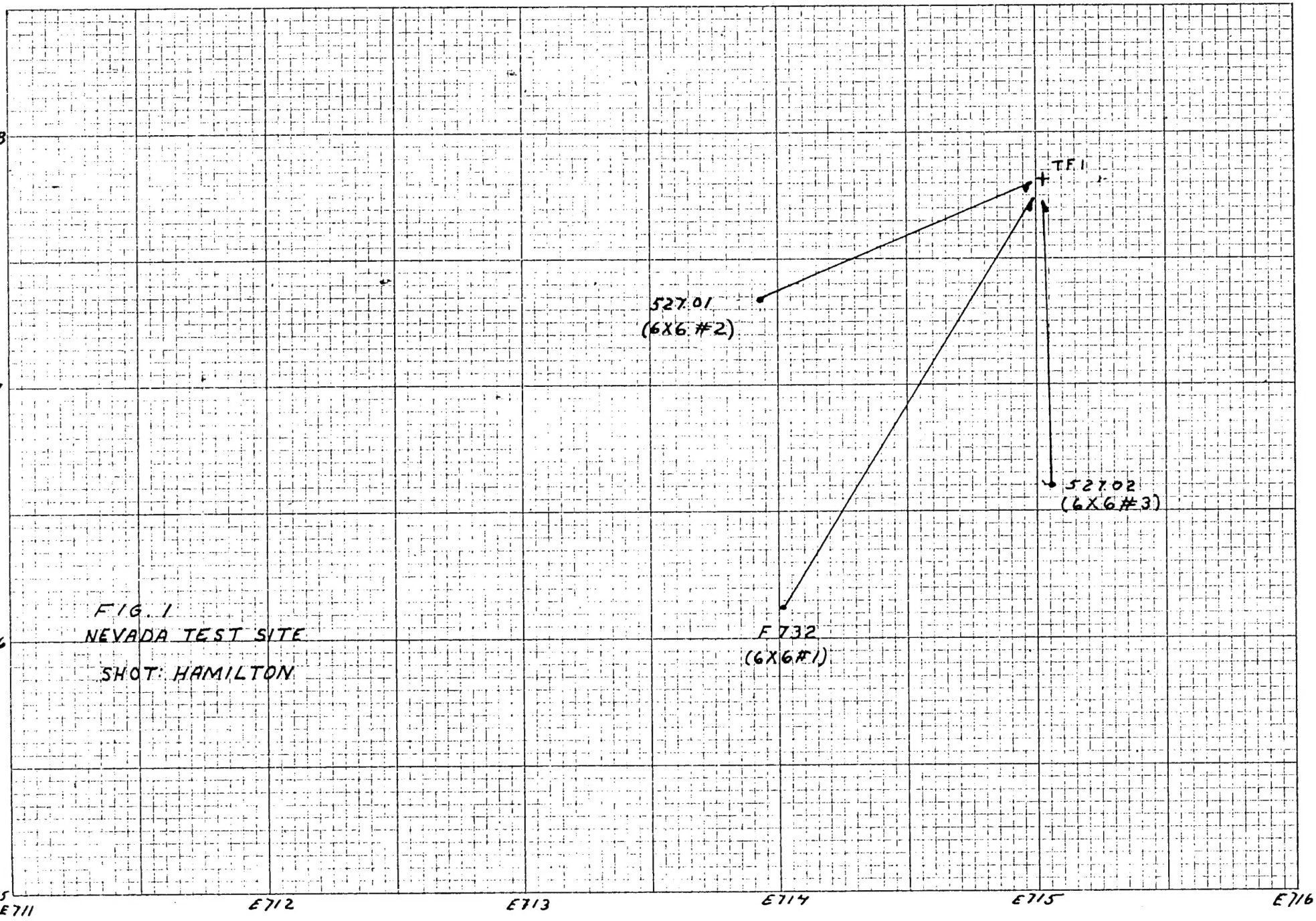


FIG. 1
NEVADA TEST SITE
SHOT: HAMILTON

Hamilton

FIG. 2

DATE 10-15-58

SURVEY DATA

GZ STA. TF1

STA.	COORDINATES			FROM Photo Sta.			DIST. HOR.		TANGENTS		ANGLES	
	N	E	Z	ΔN	ΔE	ΔZ	FT.	M.	ΔE/ΔN	ΔZ/DIST.	BRG	TILT
FF	747820	715029	3129*									
6x6 #2 527.01	747339	713933	3079	+ 481'	− 1096'	+ 50'	1196.6	3647	2.2785	0.04179	66° 18'	+ 2° 24'
6x6 #3 527.02	746600	715064	3083	+ 1220	− 35	+ 46	1220.5	372.0	.02869	0.03769	358° 21'	2° 10'
6x6 #1 F-732	746119	714012	3081	+ 1701	+ 1017	+ 48	1981.8	604.1	.59788	0.02422	30° 15'	1° 23'
	BEARING ANGLES REPRESENT TRUE AZIMUTH FROM PHOTO STA. TO GROUND ZERO											
	TILT ANGLES ARE MEASURED FROM THE PHOTO STA. TO SHOT CAB OR AIR ZERO.											
*	Includes	50 feet	height of	tower								

FORM E17(1-55 500) NAME Analysis EDGERTON, GERMESHAUSEN & GRIER INC.

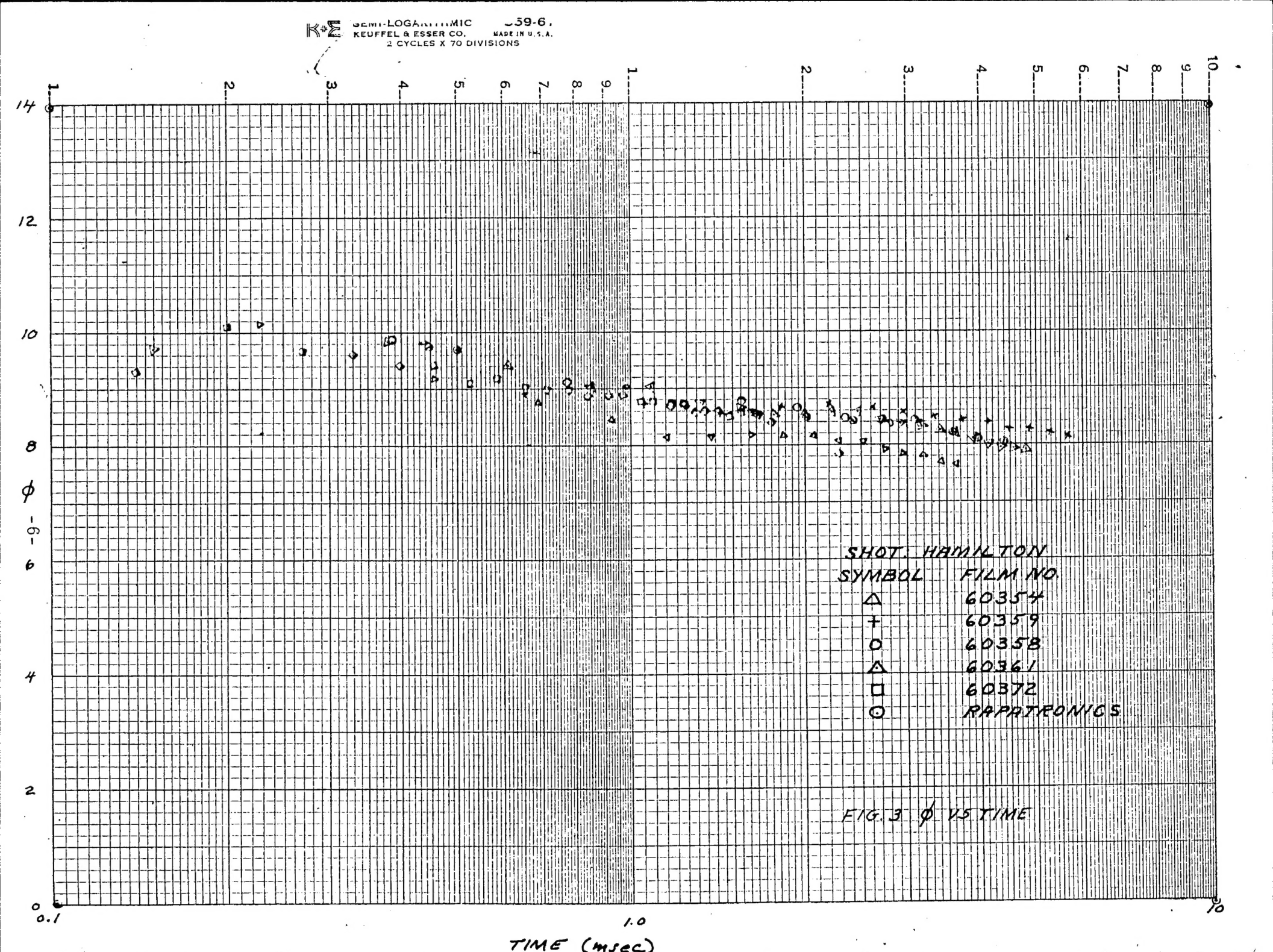


FIG. 3 φ VS TIME

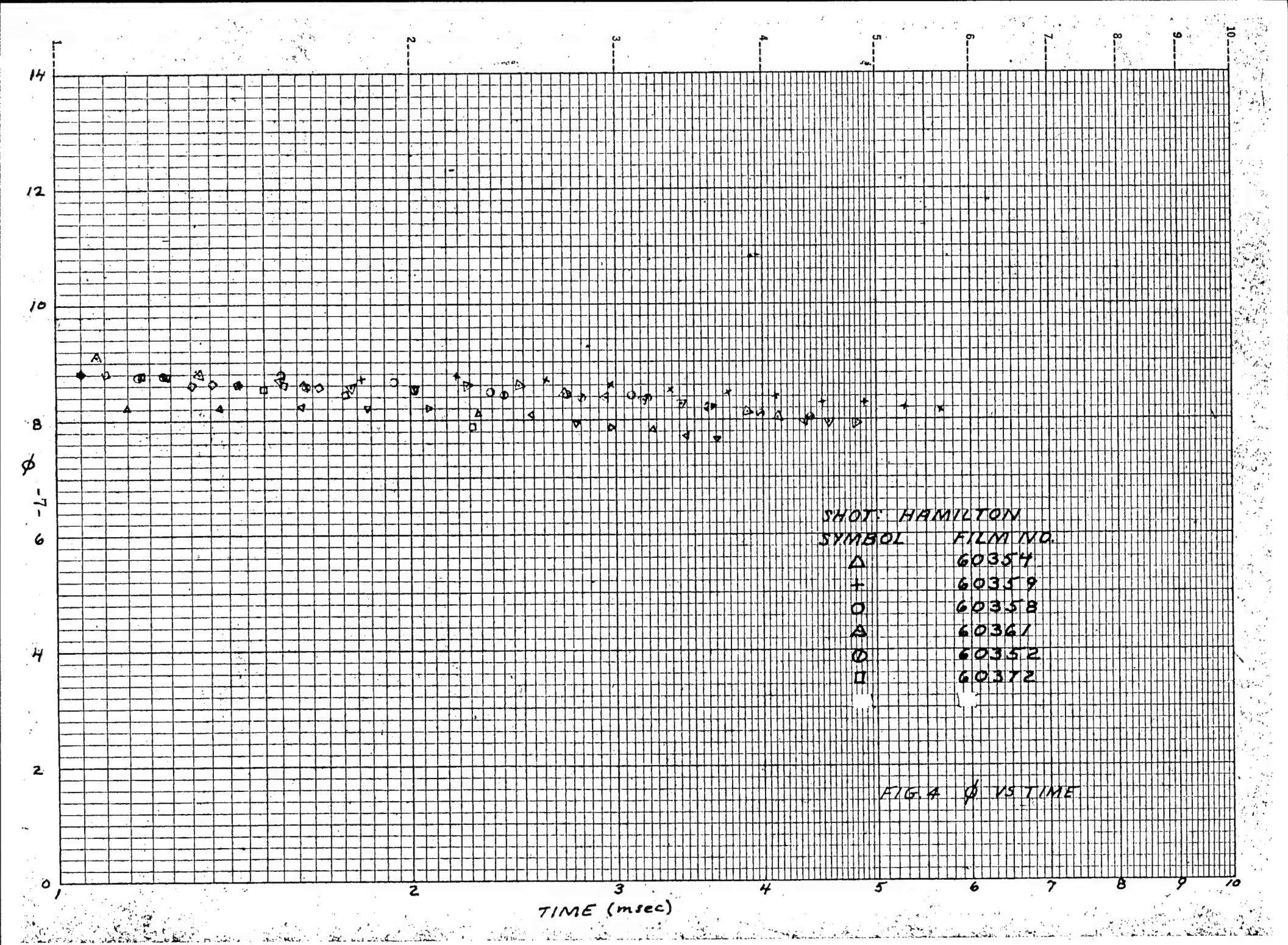


FIG. 4 φ VS TIME

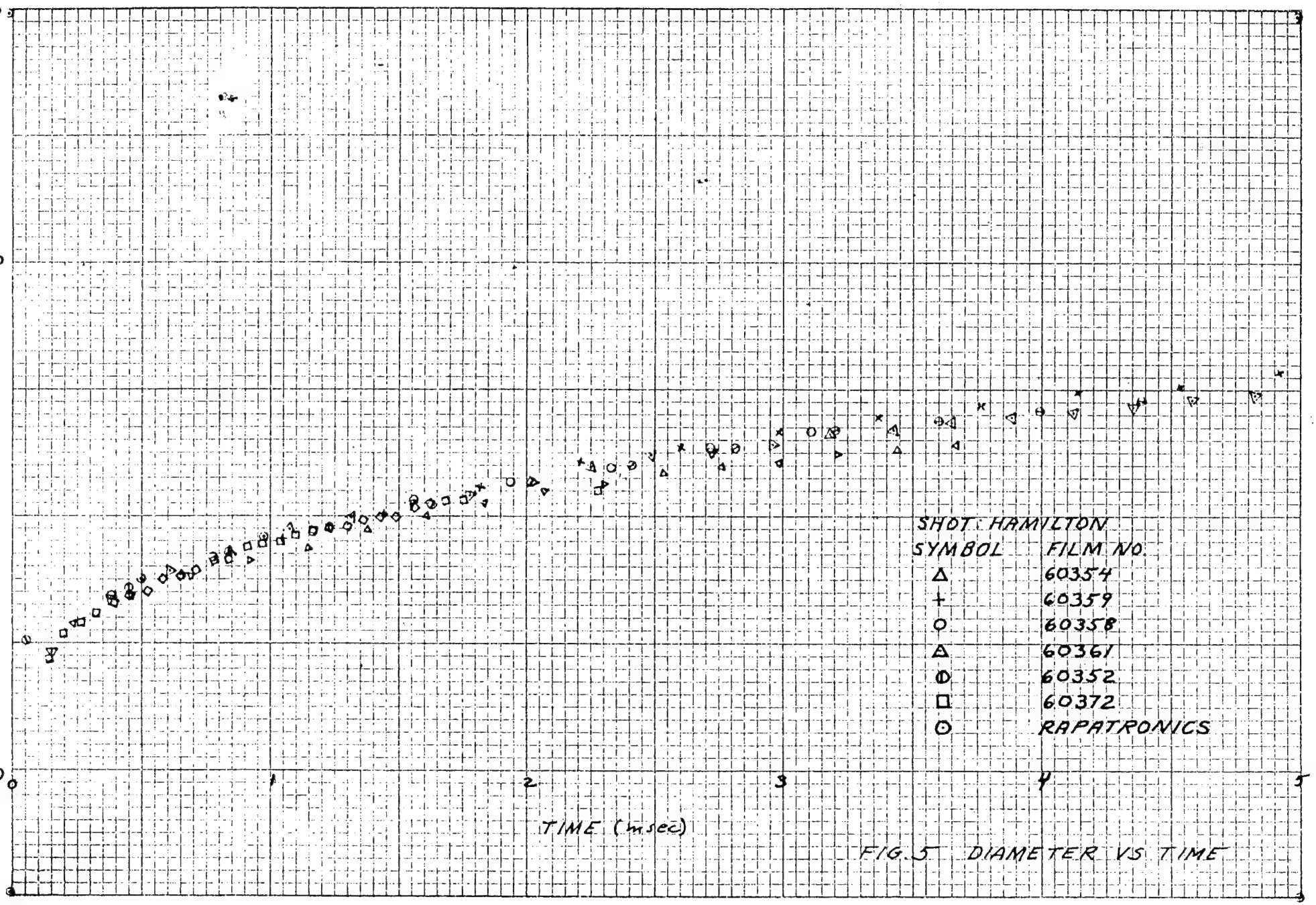


FIG. 5 DIAMETER VS TIME

Table I

Hardtack Phase II, Hamilton

Fireball Camera Distribution

Station	Camera	Qualitative Functioning
527.01 (6 x 6 No. 2)	E-34	Record
	E-7	Poor Image
	F-16 No. 2	Record
	R-4	Record
	R-3	Record
527.02 (6 x 6 No. 3)	E-25	Part of F.B. Obscured
	E-6	Record
	F-16 No. 1	Record
F-732 (6 x 6 No. 1)	FR No. 1	Record

Table II

Hardtack Phase II, Hamilton

Average Diameter vs Time

Time (in msec.)	Diameter(meters) as seen from Stations 527.01, 527.02 and F-732
0.5	7.3
1.0	9.0
1.5	10.3
2.0	11.2
2.5	12.2
3.0	12.8
3.5	13.4
4.0	14.2
4.5	14.7

Table III

Hardtack Phase II, Hamilton

Rapatronic Summary

Station	Film No.	Camera	Horizonal Range (m)	F. L. (mm)	Diameter(m)	Time(msec)
527.01 (6 x 6 No. 2)	60366	R-4	1196.6	477.39	7.37	0.4995
	60365	R-3	1196.6	477.82	8.99	0.9840

PHOTO LOADING CHART

STATION 52701 6x6 #2 EVENT HAMILTON DATE 10-15-58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER	SHUTTER RHEO.	W/M²	
MF	1112-9-02	16-100	HS Reel	60358	E-34	C-1	2500	102	ND2+ W-12	f7.5	40/80	3×10^6	
Fx	5240 604-02	16-100	HS Reel	60359	E-7	C-2	2500	63	ND-1 + W-12	f5	40/80	1.5×10^5	
Fx	5240 624-3	35-200	MIT MAG	60360	M-26	B-2	100	18.5	W-12	f7.5	170°	Weston 700	
MF	1112-F-02	16-400	Daylight Spool	60361	#2 F16/4	B-1	4000	75	ND-1 W-12	f5.6	=	1×10^5	
Fx	5240-626-2	70-50	Beatty MAG	60414	#5 CL-70	B-3	1/2	105	W-12	f9.0	1/100	Weston 700	
D KDC	2633 68N	16-50	H-MAG	60363	#22 BSP	B-4	64	9.5	=	f4.5	133°	Weston 700	
D KDC	2633 68N	16-50	H-MAG	60364	#5 GSP	B-4	64	9.5	=	f5.0	133°	Weston 800	
RP	6141-6620	2¼x3¼	RAP Holder	60365	R-4	A-1	40μs Coil	480	=	f 11	B	3×10^5	500μs delay
RP	6141-6620	↓	↓	60366	R-3	A-2	40μs Coil	↓	=	f 11	B	3×10^5	1000μs delay
					Actual		RAP	Delays					
					R-4	479	5μs	+ 20μs half coil delay					
					R-3	964 μs		+ 20μs half coil delay					

DATE FILM LOADED _____ DATE CAMERA LOADED _____ DATE EXPOSED 10-15-58

REMARKS Rev #1 10-9-58 Rev #2 10-14-58

FINAL

EDGERTON, GERMESHAUSEN & GRIER, INC.

FORM E-40

STATION NO. 527.01

STATION TYPE 6x6 #2

DISTANCE GZ 1196.6'

DISTANCE OBJECT 1197.7'

PHOTO PLAN

BRG 66°18'

EVENT HAMILTON

GZ STA. TF1

DATE 10-15-58

POSTED 10-15-58

	STATION	GZ	DIFF.	TILT
N	747 339	747 820	481	GZ + 0°00'
E	713 933	715 029	1096	OBJ 2°24'
Z	3 079	3 129*	50'	

CAMERA			LENS			FIELD TARGET H/V	AIMING			POWER			MARKER		DELAY	FILM	PURPOSE	REMARKS
NO.	NOM SPD.	RACK POS.	FOC. MM	S/N	FILTER		OBJECT	H	V	VOLTS	SHUT RHEO.	TIME ON/OFF	TYPE	S/N				
E-34	2500	C-1	102	RC 128	ND-2 W-12	.107 .084	FB	0°00'	2°04'	120DC	40/80	-1.5/+1.5	200	12	=	MF	15.1	
E-7	2500	C-2	63	ET 1207	ND-1 W-12	.176 .136	FB	0°00'	2°45'	120DC	40/80	-1.5/+1.5	200	4	=	FX	15.1	
M-26	100	B-2	18.5	201105	W-R	1.630 1.238	Cloud	0°00'	+19°	120DC	170°	-5/+30	200	12	=	FX	1.7	
#2 F16	5000	B-1	75	617086	ND-1 W-12	.147 .097	FB	0°00'	2°15'	120DC	=	-1.5/+1.5	200	4	=	MF	15.1	
#5 L70	1/2	B-3	105	RM 163	W-12	.556 .595	Cloud	0°00'	+10°30'	240DC	1/100	-5/+60	Clock	=	=	FX	↓	
22 ESP	64	L B-4	95	240 190	=	1.336 .903	Doc	0°00'	+15°10'	240C	133°	-5/+30	=	=	=	D KDC		
#5 ESP	64	R B-4	95	240259	=	1.336 .903	Doc	0°00'	+15°10'	240C	133°	-5/+30	=	=	=	D KDC	↓	
R-4	40ms Coil	A-1	480	773952	=		FB	0°00'	2°12'	115AC 24DC	B	—	FM	5	500 μs	RP	15.1	CAN #32
R-3	40ms Coil	A-2	480	774699	=		FB	0°00'	2°12'	↓	B	—	FM	5	1000 μs	RP	15.1	CAN #29
						Actual RAP Delays												
						R-4 409.5 μs ± 20 μs half coil delay												
						R-3 964.0 μs ± 20 μs half coil delay												

REMARKS Rev #1 10-5-58, Rev #2 10-14-58

* Includes 50' height of Tower

FINAL

PHOTO LOADING CHART

STATION 527.02 6x6 #3 EVENT HAMILTON DATE 10-15-58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER	SHUTTER RHEO.	W/M²	
MF	1112-9-02	16-100	HS Reel	60351	E-25	A-2	2500	102	ND-2 W-12	f7.5	40/80	3×10^6	
fx	5240 604-02	16-100	HS Reel	60352	E-6	A-3	2500	63	ND-1+ W-12	f5	40/80	1.5×10^5	
Fx	5240 6243	35-200	MIT MAG	60353	~~H~~-5	B-2	100	18.5	W-12	f7.0	170°	Weston 700	
MF	1112 F-02	16-400	Daylight Spool	60354	#1 F16-400	A-1	4000	75	ND-1+ W-12	f5.6	=	1×10^5	
Fx	5240 626-2	70-50	Beatty MAC	60355	#2 CL-70	B-1	1/2	105	W-12	f9.0	1/100	Weston 700	
D KDC	26336FN	16-50	W-MAG	60356	#20 GSP	L B-3	64	9.5	=	f5.6	133°	Weston 1000	
D KOC	26336FN	16-50	W-MAG	60357	#66 GSP	R B-3	64	9.5	=	f6.3	133°	Weston 1200	

DATE FILM LOADED _____ DATE CAMERA LOADED _____ DATE EXPOSED 10-15-58

REMARKS Rev #1 10-9-58, Rev #2 10-14-58

FINAL

EDGERTON, GERMESHAUSEN & GRIER, INC.

FORM E-40

STATION NO. 52202

STATION TYPE 6x6 #3

DISTANCE GZ 1220.5'

DISTANCE OBJECT 1221.4'

PHOTO PLAN

BRG 358°21'

EVENT HAMILTON

GZ STA. TF 1

DATE 10-15-58

POSTED 10-15-58

	STATION	G Z	DIFF.	TILT
N	746600	747 820	1220.	GZ −0°10'
E	715064	715 029	−35	OBJ 2°10'
Z	3 083	3 129*	46	

CAMERA			LENS			FIELD TARGET H/V	AIMING			POWER			MARKER		DELAY	FILM	PURPOSE	REMARKS
NO.	NOM SPD.	RACK POS.	FOC. MM	S/N	FILTER		OBJECT	H	V	VOLTS	SHUT RHEO.	TIME ON/OFF	TYPE	S/N				
E-25	2500	A 2	102	RA 549	ND2 +W-12	.108 .084	F.B.	0°00'		120DC	40/80	−1.5/+15	200	101	=	MF	15.1	
E-6	2500	A 3	63	ET 1254	ND-1 W-12	.176 .115	F.B.	0°00'		120DC	40/80	−1.5/+15	200	14	=	Fx	15.1	
M-5	100	B-2	18.5	365969	W-12	1.631 1.239	Cloud	0°00'		120DC	170°	−5/+30	200	101	=	Fx	15.1	
#1 F16	4000	A-1	75	617071	ND-1 W-12	.147 .098	F.B.	0°00'		20DC	=	−1.5/+1.5	200	14	=	MF	15.1	
#2 Ck70	1/2	B-1	105	RM 210	W-12	.687 .665	Cloud	0°00'		24DC	1/100	−5/+6m	Clock	=	=	Fx	15.1	
20 GSP	64	L B-3	9.5	2551810	=	1.338 .900	Doc.	0°00'		24DC	133°	−5/+30	=	=	=	D KDC	15.1	
66 GSP	64	R B-3	9.5	255319	=	1.338 .900	Doc.	0°00'		24DC	133°	−5/+30	=	=	=	D KDC	15.1	

REMARKS Rev #1 10-9-58, Rev #2 10-14-58

* Includes 50' height of Tower

FINAL

FORM E-60 A

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO LOADING CHART

STATION F 732 6x6 #1 EVENT HAMILTON DATE 10-15-58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER	SHUTTER RHEO.	W/M^2	
MF		35x9	Cassette	60372	PR #1	—	15,000	15"	W-12	f 12	MAX	3.5×10^5	

DATE FILM LOADED _____ DATE CAMERA LOADED _____ DATE EXPOSED 10-15-58

REMARKS _____

FINAL

FORM E-40

EDGERTON, GERMESHAUSEN & GRIER, INC.

STATION NO. F-732

STATION TYPE 6x6 #1

DISTANCE GZ 1981.8'

DISTANCE OBJECT 1982.4'

PHOTO PLAN

BRG 30°15'

EVENT HAMILTON

GZ STA. TF1

DATE 10-15-58

POSTED 10-15-58

	STATION	GZ	DIFF.	TILT
N	746119	747 820	1701.	GZ −0°3'
E	714012	715 029	1017	OBJ 1°23'
Z	3081	3 129*	48	

CAMERA			LENS			FIELD TARGET H/V	AIMING			POWER			MARKER		DELAY	FILM	PURPOSE	REMARKS
NO.	NOM SPD.	RACK POS.	FOC. MM	S/N	FILTER		OBJECT	H	V	VOLTS	SHUT RHEO.	TIME ON/OFF	TYPE	S/N				
FR#1	15,000	—	15"	4498166	W-12		FB	0°00'		115AC 240C	MAX	-15/+15	200	1	—	MF	15.1	

REMARKS

* Includes 50' height of tower.

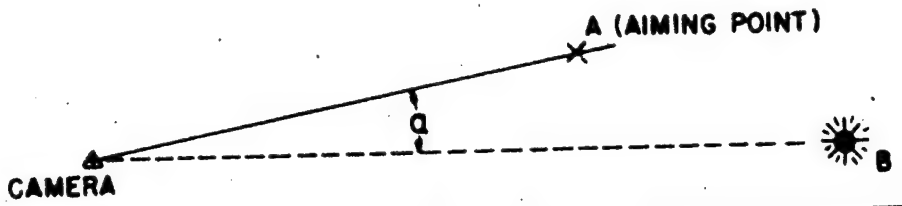
FINAL

FORM E-60 A

EDGERTON, GERMESHAUSEN & GRIER, INC.

CAMERA DATA & CALCULATIONS

FILM NO. 60366	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. R3	EQ. AP.		DATE: 10/15/58



HORIZONTAL PROJECTION

A. $R^{O}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00'	β = 2° 12'	H_B = 3129 ft
cos α = 1.0000	cos β = 0.99926	H_C = 3079 ft
CB_h = 364.7 m	sin β = 0.03839	ΔH = 50 ft = 15.2 m
$CB_h \cos\alpha \cos\beta$ = 364.4 m	$\Delta H \sin\beta$ = 0.6 m	$R^{O}/_{A}$ = 365.0 m

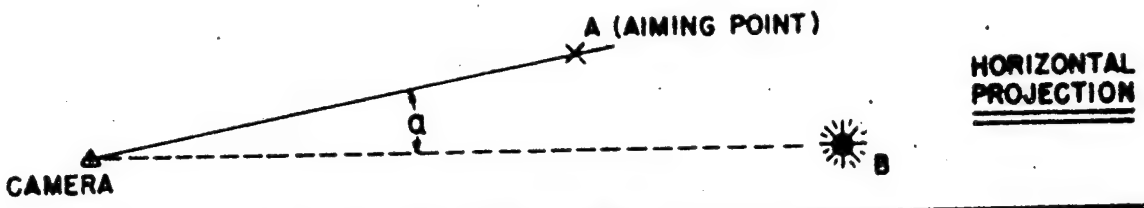
B. FOCAL LENGTH 477.39 mm (774699)

C. MAGNIFICATION FACTOR (meters/in.) 19.43

D. ZERO TIME CORRECTION 0.9840 ms delay

CAMERA DATA & CALCULATIONS

FILM NO. 60365	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. R4	EQ. AP.		DATE: 10/15/58



A. $R^{0}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 2° 12′	H_B = 3129 ft
$\cos\alpha$ = 1.0000	$\cos\beta$ = 0.99926	H_C = 3079 ft
CB_h = 364.7 m	$\sin\beta$ = 0.03839	ΔH = 50 ft = 15.2 m
$CB_h \cos\alpha \cos\beta$ = 364.4 m	$\Delta H \sin\beta$ = 0.6 m	$R^{0}/_{A}$ = 365.0 m

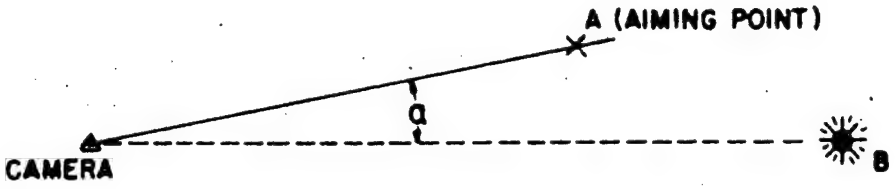
B. FOCAL LENGTH 477.82 mm (773952)

C. MAGNIFICATION FACTOR (meters/in.) 19.41

D. ZERO TIME CORRECTION 0.4995 ms delay

CAMERA DATA & CALCULATIONS

FILM NO. 60359	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E 7	EQ. AP.		DATE: 10/15/58



HORIZONTAL PROJECTION

A. $R^{O}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00'	β = 2° 45'	H_B = 3129 ft
$\cos\alpha$ = 1.0000	$\cos\beta$ = 0.99885	H_C = 3079 ft
CB_h = 364.7 m	$\sin\beta$ = 0.04798	ΔH = 50 ft = 15.2 m
$CB_h \cos\alpha \cos\beta$ = 364.3 m	$\Delta H \sin\beta$ = 0.7 m	$R^{O}/_{A}$ = 365.0 m

B. FOCAL LENGTH 64.1 mm (ET-1207)

C. MAGNIFICATION FACTOR (meters/in.) 144.6

D. ZERO TIME CORRECTION 0.28 ms

DIAMETER MEASUREMENTS

SHOT HAMILTON FILM NO. 60359

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xx.xx	FLEXOWRITER t (ms)
0	28.90				7.58		0.66
1		0152	0151		8.95		1.05
2		0185	0173		9.95		1.44
3		0204	0194		11.10		1.82
4		0229	0215		12.08		2.21
5		0248	0235		12.93		2.60
6		0258	0251		13.33		2.98
7		0271	0262		13.88		3.37
8		0281	0274		14.40		3.76
9		0289	0287		14.88		4.14
10		0299	0296		15.23		4.53
11		0306	0303		15.73		4.91
12		0313	0316		16.05		5.30
13		0321	0321		16.40		5.69
14		0328	0328				

READ BY PLW GGO TYPED BY

DATE 10/23/58 DATE

REMARKS:

EDGERTON, GERMESHAUSEN & GRIER, INC.

FIREBALL CALCULATIONS

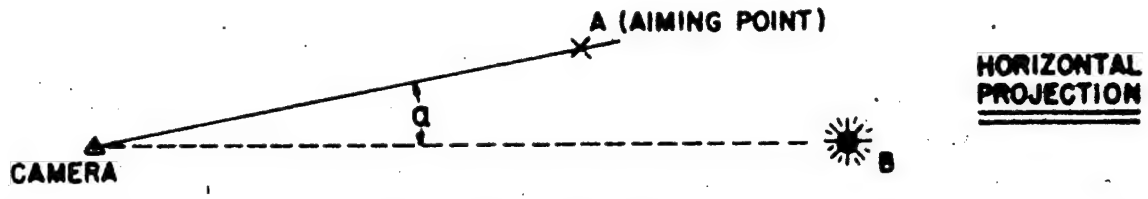
SHOT Hamilton FILM NO. 60359

DATE 1-22-59

D	t	ln D	Int	$t^{2/5}$	ϕ
7.58	.66	2.025 51	41559 -	.8 46845	8950
895	105	2 19172	4876	1019697	8777
995	144	2297 50	36469	1157056	8599
1110	182	2406 87	59887	1270678	8735
1208	221	2491 49	79293	1373243	8796
1273	260	2543 94	95543	1465468	8686
1333	298	2590 03	1091 89	1547680	8612
1388	337	2630 48	1214 94	1625763	8537
1440	376	2667 28	1324 48	1698585	8477
1488	414	2700 09	1420 77	1765278	8429
1523	453	2723 34	1510 77	1829989	8322
1573	491	2755 65	1591 29	1898885	8323
1605	530	2775 79	1667 68	1948525	8236
1640	569	2797 36	1738 65	2004633	8181

CAMERA DATA & CALCULATIONS

FILM NO. 60358	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E34	EQ. AP.		DATE: 10/15/58



A. $R^{o}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 2° 04′	H_B = 3129 ft
$\cos\alpha$ = 1.0000	$\cos\beta$ = 0.99935	H_C = 3079 ft
CB_h = 364.7 m	$\sin\beta$ = 0.03606	ΔH = 50 ft = 15.2 m
$CB_h \cos\alpha \cos\beta$ = 364.5 m	$\Delta H \sin\beta$ = 0.55 m	$R^{o}/_{A}$ = 365.1 m

B. FOCAL LENGTH 101.6 mm (RC 128)

C. MAGNIFICATION FACTOR (meters/in.) 91.27

D. ZERO TIME CORRECTION 0.004 ms

E-34

DIAMETER MEASUREMENTS

SHOT Hamilton FILM NO. 60358

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} xxx.xx (m)	FLEXOWRITER t (ms)
0	Fireball inside cab						0.39
1	29.00	0218	0214		6.80		0.78
2		0270	0258		8.32		1.17
3		0305	0286		9.32		1.56
4		0339	0330		10.55		1.94
5		0368	0349		11.31		2.33
6		0385	0372		11.94		2.72
7		0403	0399		12.63		3.11
8		0421	0425		13.32		

READ BY JB JSO TYPED BY

DATE 10/15/58 10/15/58 DATE

REMARKS:

EDGERTON, GERMESHAUSEN & GRIER, INC.

FIREBALL CALCULATIONS

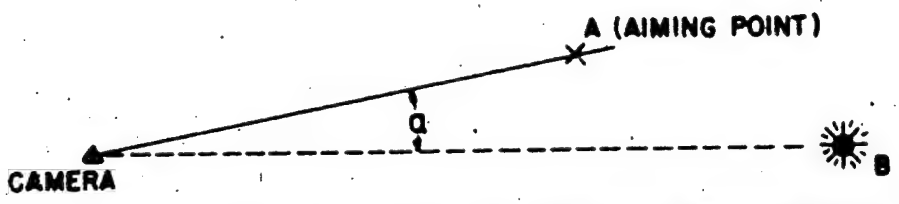
SHOT Hamilton FILM NO. 60358

DATE 1-22-59

D	t	ln D	ln t	$t^{2/5}$	ϕ
6.80	.39	1.91685	.94153 -	.686180	9909
832	78	211872	24844 -	905399	9189
932	117	223221	15693	1064784	8752
1055	156	235609	44476	1194711	8830
1131	194	242561	66269	1303533	8676
1194	233	247983	84579	1402588	8512
1263	272	253604	100056	1492163	8464
1332	311	258927	113461	1574355	8460

CAMERA DATA & CALCULATIONS

FILM NO. 60361	STATION NO. 527.01 6x6 #2	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. F-16 #2	EQ. AP.		DATE: 10/15/58



HORIZONTAL PROJECTION

A. $R^{O}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 2° 15′	H_B = 3129 ft
$\cos\alpha$ = 1.0000	$\cos\beta$ = 0.99923	H_C = 3079 ft
CB_h = 364.7 m	$\sin\beta$ = 0.03926	ΔH = 50 ft = 15.2 m
$CB_h \cos\alpha \cos\beta$ = 364.4 m	$\Delta H \sin\beta$ = 0.6 m	$R^{O}/_{A}$ = 365.0 m

B. FOCAL LENGTH 78.06 mm (617086)

C. MAGNIFICATION FACTOR (meters/in.) 118.8

D. ZERO TIME CORRECTION 0.15 ms

DIAMETER MEASUREMENTS

SHOT Hamilton FILM NO. 60361

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} xxx.xx (m)	FLEXOWRITER t (ms)
0	48.15	0176	0195		4.58		0.15
1		0273	0273		6.74		0.38
2		0316	0315		7.79		0.61
3		0342	0349		8.53		0.85
4	28.90	0227	0230		9.39		1.08
5		0239	0241		9.86		1.32
6		0249	0255		10.36		1.55
7		0260	0265		10.79		1.78
8		0276	0276		11.34		2.02
9		0288	0293		11.94		2.25
10		0301	0303		12.41		2.48
11		0309	0306		12.64		2.72
12		0314	0315		12.93		2.95
13		0322	0323		13.25		3.18
14		0328	0331		13.54		3.42
15		0335	0337		13.81		3.65
16		0341	0341		14.02		3.88
17		0346	0344		14.18		4.12
18		0351	0349		14.39		4.35
19		0356	0358		14.67		4.58
20		0364	0363		14.94		4.82

READ BY GGO LW TYPED BY

DATE 10/28/58 DATE

REMARKS:

FIREBALL CALCULATIONS

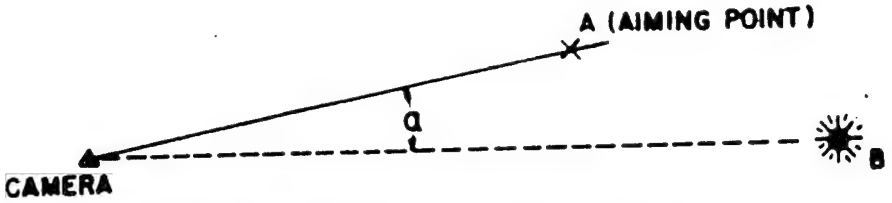
SHOT Hamilton FILM NO. 60361

DATE 1-22-59

D	t	ln D	Int	$t^{2/5}$	ϕ
4.58	.15	1.52174	1.89705 -	.468217	9.781
6.74	38	1.90799	.967 51 -	6.79086	9925
7.79	61	2.05285	49437 -	8.20574	9493
8.53	85	2.14366	16245 -	9.37085	9102
9.39	1.08	2.23968	7690	10.31239	9105
9.86	1.32	2.28844	27763	11.17454	8823
10.36	1.55	2.33795	43833	11.91642	8693
10.79	1.78	2.37856	57666	12.59438	8567
11.34	2.02	2.42826	70308	13.24763	8560
11.94	2.25	2.47983	81086	13.83128	8632
12.41	2.48	2.51846	90818	14.38027	8629
12.64	2.72	2.53684	1.00056	14.92163	8470
12.93	2.95	2.55954	1.08177	15.41426	8388
13.25	3.18	2.58400	1.15688	15.88441	8341
13.54	3.42	2.60567	1.22967	16.35373	8279
13.81	3.65	2.62542	1.29478	16.78525	8227
14.02	3.88	2.64053	1.35591	17.20068	8150
14.18	4.12	2.65188	1.41592	17.61863	8048
14.39	4.35	2.66659	1.47024	18.00558	7991
14.67	4.58	2.68587	1.52174	18.38039	7981
14.94	4.82	2.70411	1.57280	18.75959	7963

CAMERA DATA & CALCULATIONS

FILM NO. 60352	STATION NO. 527.02 6x6 #3	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. E 6	EQ. AP.		DATE: 10/15/58



A. $R^0/_A = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00'	β = 2° 10'	H_B = 3129 ft
cos α = 1.0000	cos β = 0.99929	H_C = 3083 ft
CB_h = 372.0 m	sin β = 0.03781	ΔH = 46 ft = 14 m
$CB_h \cos\alpha \cos\beta$ = 371.7 m	ΔH sin β = 0.5 m	$R^0/_A$ = 372.2 m

FOCAL LENGTH 63.91 mm (ET 1254)

MAGNIFICATION FACTOR (meters/in.) 147.9

ZERO TIME CORRECTION 0.05 ms

FIREBALL CALCULATIONS

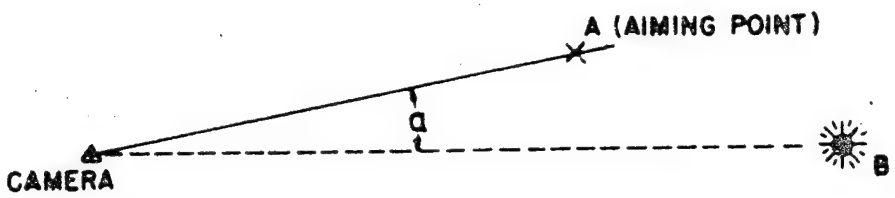
SHOT Hamilton FILM NO. 60352

DATE 1-22-59

t	ln D	ln t	$t^{2/5}$	ϕ
.05	1.61343	2.99572 -	.301722	16.637
45	1.96286	.79845 -	.726597	9799
84	2.14248	.17429 -	.932657	9135
1.23	2.25342	.20696	1.086309	8763
1.63	2.34563	.48865	1.215873	8586
2.02	2.42384	.70308	1.324763	8522
2.41	2.48568	.87955	1.421653	8447
2.81	2.54158	1.03313	1.511726	8400
3.20	2.59452	1.16315	1.592432	8408
3.60	2.62252	1.28099	1.669287	8249
3.99	2.65047	1.38386	1.739412	8140
4.38	2.68040	1.47711	1.805514	8080

CAMERA DATA & CALCULATIONS

FILM NO. 60354	STATION NO. 527.02 6x6 #3	TEST HAMILTON	CALCULATED BY: GGO
CAMERA NO. F16 #1	EQ. AP.		DATE: 10/15/58



HORIZONTAL PROJECTION

A. $R^{\circ}/_{A} = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

α = 0° 00′	β = 2° 10′	H_B = 3129 ft
$\cos \alpha$ = 1.0000	$\cos \beta$ = 0.99929	H_C = 3083 ft
CB_h = 372.0 m	$\sin \beta$ = 0.03781	ΔH = 46 ft = 14 m
$CB_h \cos \alpha \cos \beta$ = 371.7 m	$\Delta H \sin \beta$ = 0.5 m	$R^{\circ}/_{A}$ = 372.2 m

B. FOCAL LENGTH 77.96 mm (617071)

C. MAGNIFICATION FACTOR (meters/in.) 121.3

D. ZERO TIME CORRECTION 0.002 ms

DIAMETER MEASUREMENTS

amilton

FILM NO. 60354

).	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xxx.xx	t (ms)
	48.15	XXXX	XXXX		—		
		0222	0227		5.66		0.23
		0267	0270		6.77		0.46
		0300	0303		7.60		0.69
		0326	0326		8.22		0.92
		0346	0342		8.67		1.15
	28.90	0221	0224		9.35		1.38
		0239	0237		10.00		1.61
		0251	0247		10.46		1.84
		0262	0261		10.98		2.07
		0271	0268		11.32		2.30
)		0278	0279		11.74		2.53
L		0286	0283		11.95		2.76
2		0291	0290		12.20		2.98
3		0297	0298		12.50		3.21
4		0303	0301		12.68		3.44
5		0309	0307		12.94		3.67
6							

BY GGO JEC TYPED BY

10/28/58 DATE

ARKS:

EDGERTON, GERMESHAUSEN & GRIER, INC.

FIREBALL CALCULATIONS

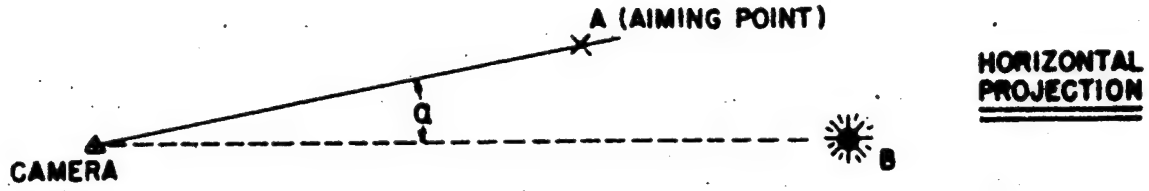
Lon _____ FILM NO. 60354

DATE 1-22-59

ln D	lnt	$t^{2/5}$	ϕ
33336	1.46974 -	.555493	10189
11243	77648 -	733011	9235
28814	37112 -	862042	8816
06662	8332 -	967219	8498
59994	13968	1057464	8198
35442	32211	1137514	8219
02666	47631	1209884	8265
47754	60980	1276243	8195
96601	72752	1337776	8207
26649	83284	1395338	8112
62993	92814	1449555	8099
80667	101517	1500904	7961
01138	109189	1547680	7882
25569	116627	1594422	7839
40000	123551	1639194	7735
50031	130025	1682199	7692

CAMERA DATA & CALCULATIONS

NO. 60372	STATION NO. F-732 6x6 #1	TEST HAMILTON	CALCULATED BY: GGO
ERA NO. FR #1	EQ. AP.		DATE: 10/15/58



$R^{0}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

0° 00′	β = 1° 23′	H_B = 3129 ft
α = 1.0000	$\cos\beta$ = 0.99971	H_C = 3081 ft
= 604.1 m	$\sin\beta$ = 0.02414	ΔH = 48 ft = 14.6 m
$\cos\alpha \cos\beta$ = 603.9 m	$\Delta H \sin\beta$ = 0.4 M	$R^{0}/_{A}$ = 604.3 m

FOCAL LENGTH

MAGNIFICATION FACTOR (meters/in.)

ZERO TIME CORRECTION 0.006 ms

L

DIAMETER MEASUREMENTS

SHOT Hamilton FILM NO. 60372

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xxx.xx	FLEXOWRITER t (ms)
0	19.33	XXXX	XXXX		—		—
1		XXXX	XXXX		—		—
2		0134	0139		4.26		0.14
3		0169	0176		5.31		0.20
4		0182	0190		5.77		0.27
5		0198	0200		6.19		0.33
6		0212	0211		6.56		0.40
7		0222	0230		6.94		0.46
8		0235	0235		7.10		0.53
9		0249	0249		7.49		0.59
10		0253	0255		7.67		0.66
11		0257	0259		7.89		0.72
12		0267	0265		8.19		0.79
13		0273	0276		8.34		0.85
14		0279	0283		8.65		0.92
15		0281	0286		8.87		0.98
16		0288	0289		8.97		1.05
17		0297	0301		9.18		1.11
18		0300	0304		9.36		1.18
19		0306	0307		9.53		1.24
20		0312	0314		9.58		1.31
21		0317	0320		9.81		1.37
22		0325	0326		9.96		1.44
23		0329	0330		10.02		1.50
24		0335	0336		10.33		1.57
25		0336	0341		10.46		1.63
26		0342	0343		10.55		1.69
27		0348	0349		10.56		1.76
35		0354	0355		10.99		2.28

READ BY JEC RCS TYPED BY JEC

DATE 1/14/59 DATE 1/14/59

REMARKS:

FIREBALL CALCULATIONS

SHOT Hamilton FILM NO. 60372

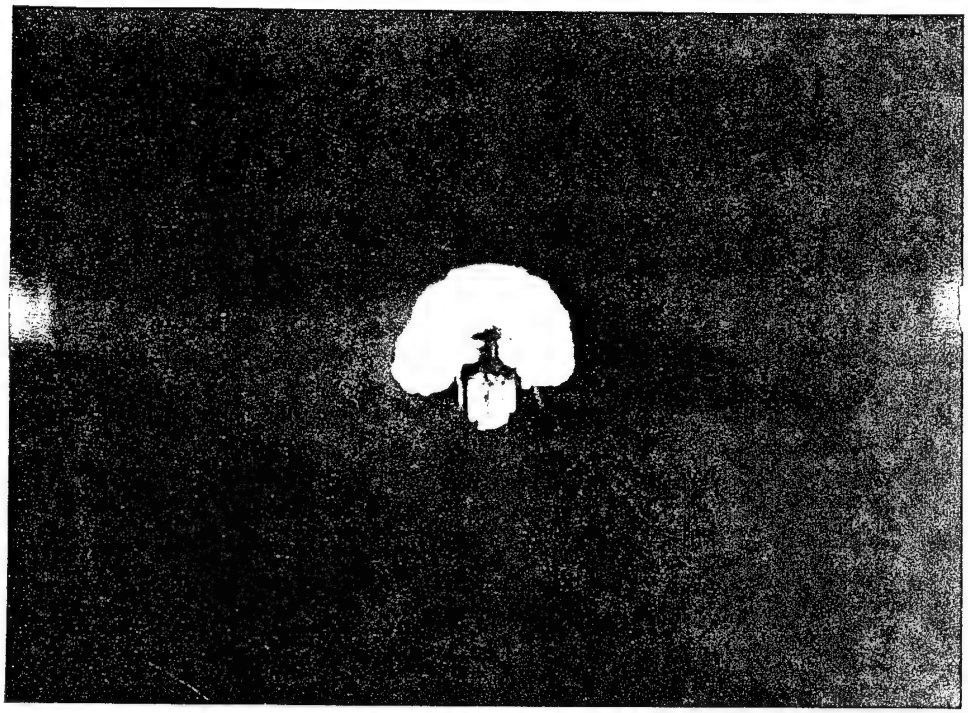
DATE 1-22-59

D	t	ln D	Int	$t^{2/5}$	ϕ
4.26	.14	1.44934	1.96607 -	.455467	9353
5.31	20	1669 56	1 60945 -	5 25303	10108
5 77	27	1 75260	1 30940 -	5 922 88	9741
6 19	33	1 82285	1 10864 -	6 41812	9644
6 56	40	1 88091	91621 -	6 93164	9463
6 94	46	1 93724	77648 -	7 33011	9467
7 10	53	1 96005	63490 -	7 75720	9152
7 49	59	2 01355	52770 -	8 09707	9250
7 67	66	2 03732	41559 -	8 46845	9057
7 89	72	2 06562	32854 -	8 76851	8998
8 19	79	2 10296	23569 -	9 10028	8999
8 34	85	2 12112	16245 -	9 37085	8899
8 65	92	2 15763	8332 -	9 67219	8943
8 87	98	2 18275	2023 -	9 91939	8942
8 97	105	2 19396	4876	10 19697	8796
9 18	111	2 21709	10428	10 42596	8804
9 36	118	2 23649	16544	10 68416	8760
9 53	124	2 25446	21506	10 89836	8744
9 58	131	2 25969	27002	11 14057	8599
9 81	137	2 28337	31483	11 34208	8649
9 96	144	2 29851	36469	11 57056	8608
10 02	150	2 30465	40553	11 76111	8519
10 33	157	2 33505	45115	11 97769	8624
10 46	163	2 34754	48865	12 15873	8602
10 55	169	2 35609	52479	12 33578	8552
10 56	176	2 35704	56537	12 53761	8422
10 99	228	2 39692	82411	13 90473	7903

APPENDIX

HARDTACK PHASE II, HAMILTON

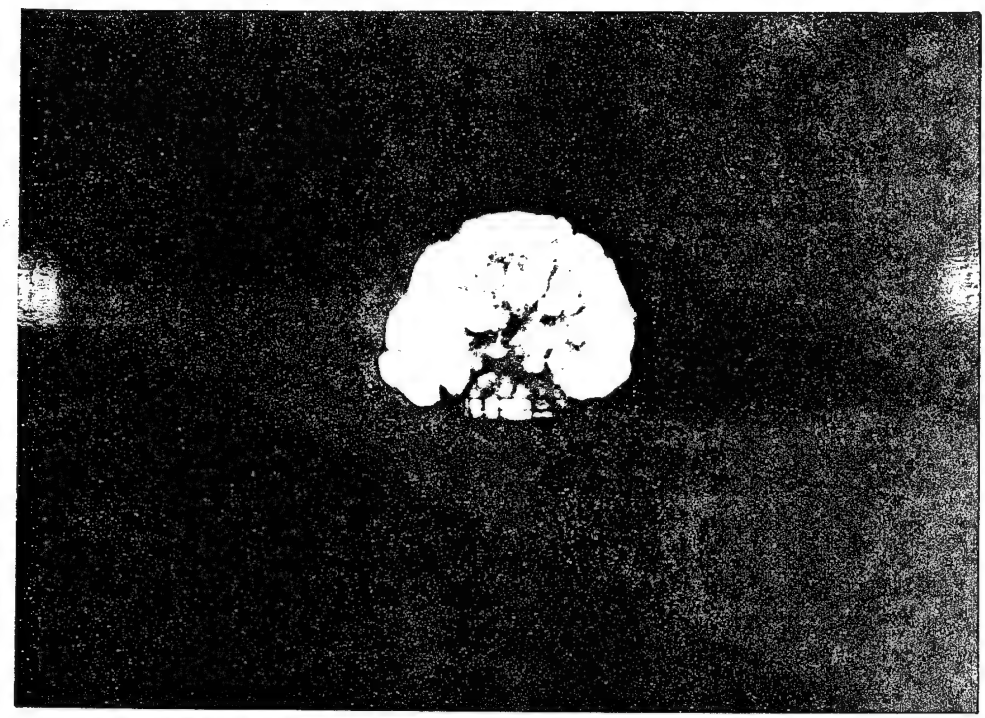
PHOTOGRAPHIC EXAMPLES



Camera: F-16 No. 2

Station: 527.01

Time: 0.38 msec



Camera: F-16 No. 2

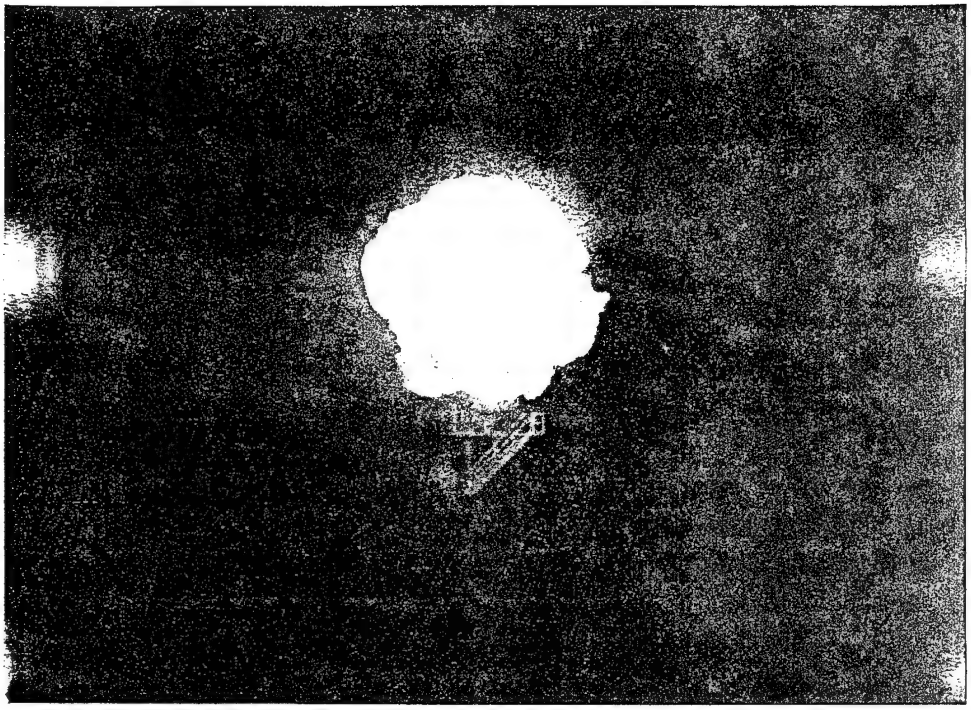
Station: 527.01

Time: 1.08 msec

Camera: F-16 No. 2

Station: 527.01

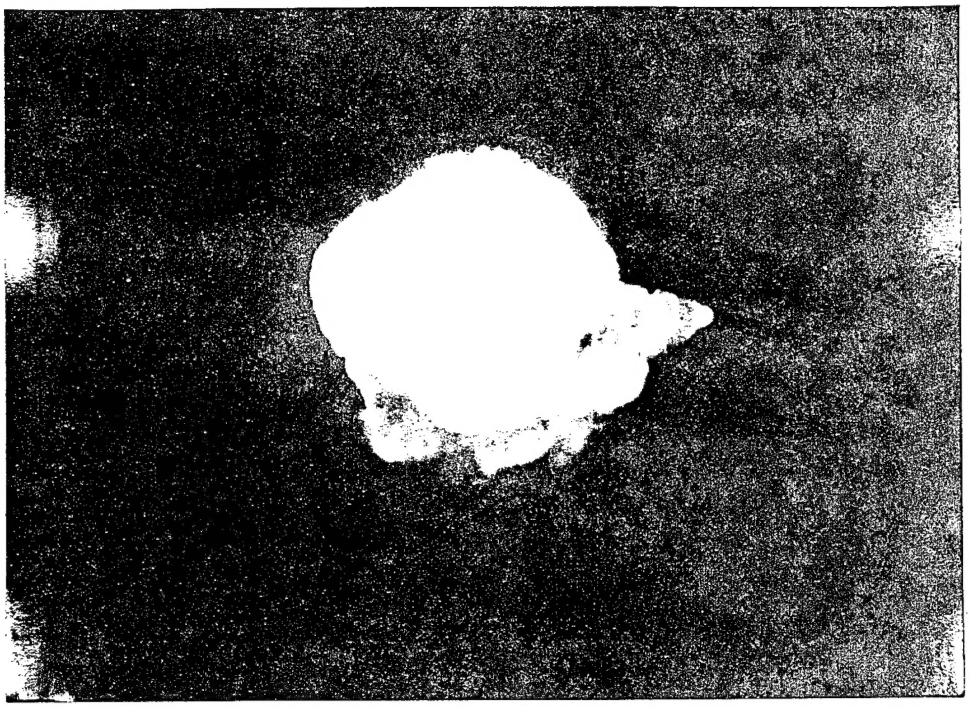
Time: 2.02 msec



Camera: E-6

Station: 527.02

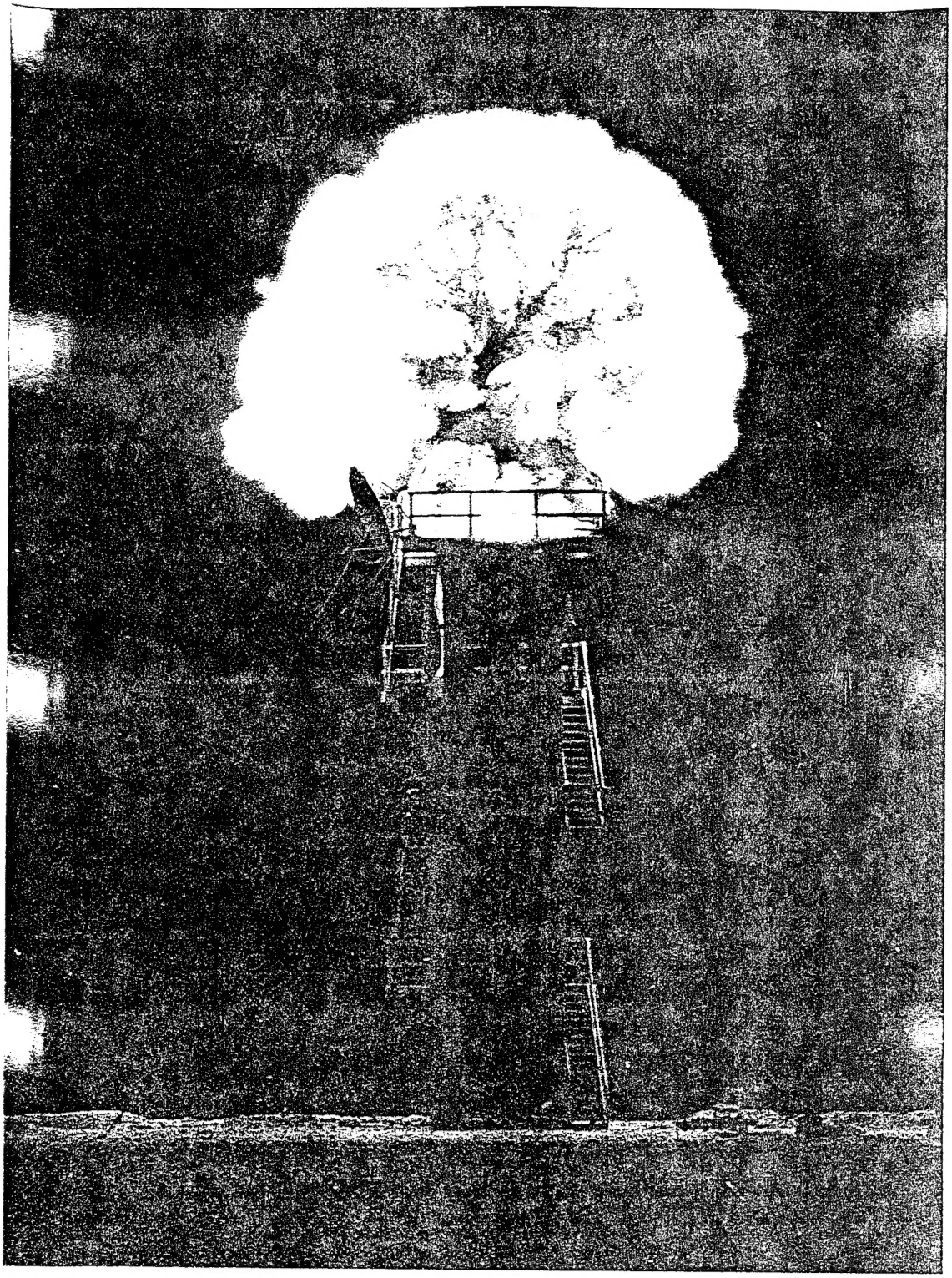
Time: 2.02 msec



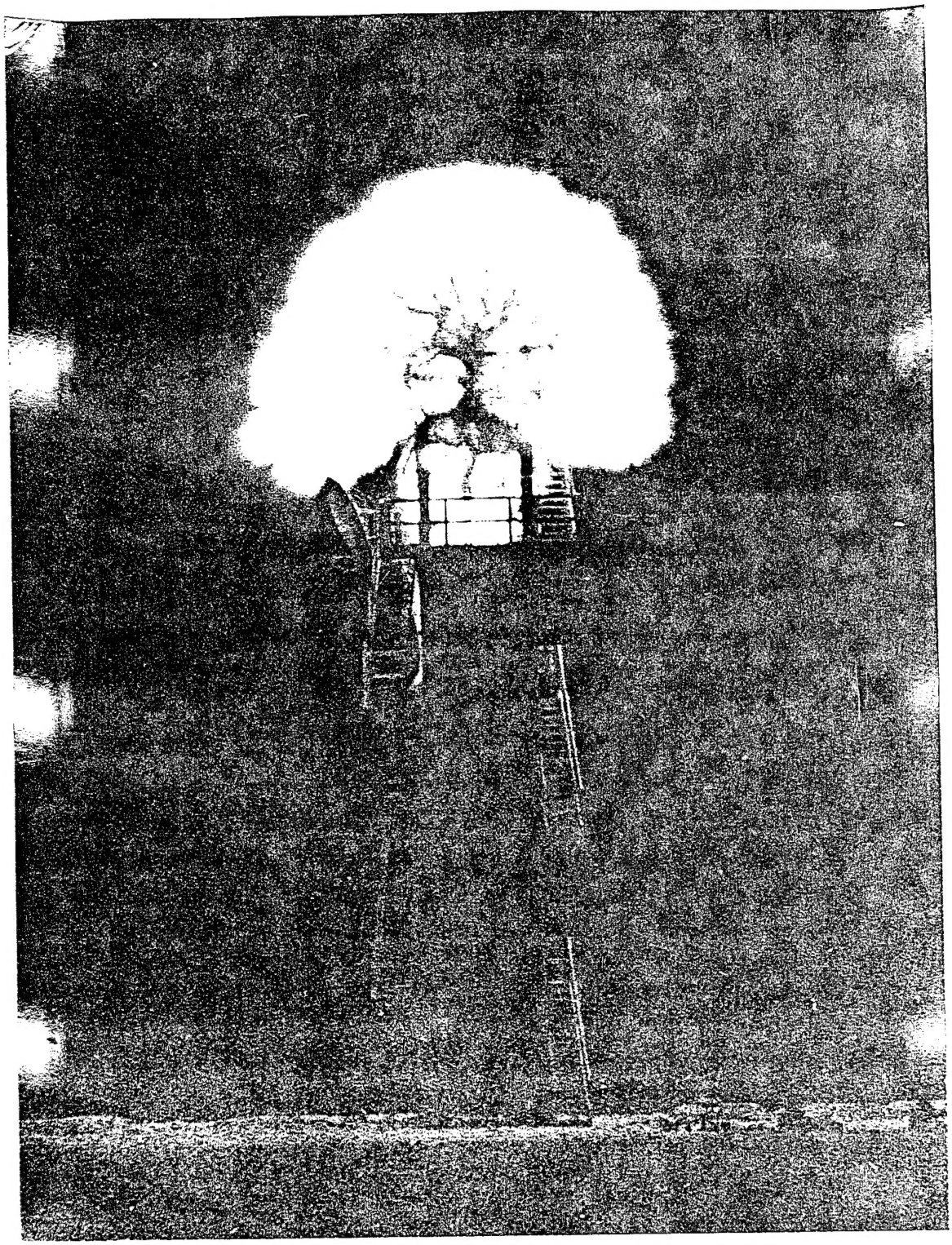
Camera: E-6

Station: 527.02

Time: 6.74 msec



Camera: R-4
Station: 527.01
Time: 0.4995 msec



Camera: R-3
Station: 527.01
Time: 0.9840 msec

Distribution

Copies to:

1	Dr. G. W. Johnson, Test Director
1	Dr. H. B. Keller, LRL Test Group Director
1	Dr. W. E. Ogle, LASL Test Group Director
1	Dr. L. S. Wouters, LRL
1	Dr. J. F. Mullaney, Group J-10,
1	EG&G, Boston
1	EG&G, Las Vegas